NASA-CR-194478

ELECTROKINETIC TRANSPORT OF HETEROGENEOUS PARTICLES IN SUSPENSIONS

Status Report

for Period January 1, 1993-December 31, 1993

John L. Anderson

Professor and Head
Department of Chemical Engineering
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213

October 1, 1993

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH GRANT NO. NAG8-964

STATUS REPORT

Electreokinetic Transport of Heterogeneous Particles in Suspension

The focus of research over the past nine months has been on a theory for the electrophoresis of slender particles and on trajectory analysis of colloidal doublets rotating in electric fields. Brief summaries are given below:

1. We have developed a general theory for the electrophoretic motion of "slender bodies". Such particles have a long contour length ($2l$) relative to their maximum width (2b). When the double layer is very thin relative to b, the theory is correct to $O(\varepsilon^2 \ln\varepsilon)$ where $\varepsilon = b/l$. These particles can be straight, such as cylinders or prolate spheroids, and curved, such as a torus and a helix. Two physical situations are considered: the particle has a **zeta potential** (i.e., charge per length) which is a **function of position** along the contour of the particle and is placed in a fluid experiencing a constant electric field in the absence of the particle; and a **uniformly charged** particle in an **inhomogeneous electric field**. In both situations the particle rotates and translates at velocities that depend on the geometry of the particle, the distribution of charge along the particle's contour, and the inhomogeneity of the applied electric field.

   This research was reported at the symposium on "Polyelectrolytes" at the American Chemical Society meeting, Denver, April, 1993, and will appear in the published volume of (reviewed) papers from this symposium. The title of our paper is "Electrophoresis of Nonuniformly Charged Chains" by John L. Anderson and Yuri Solomentsev. Five copies of this paper are enclosed with this report. We are currently working on a paper for publication which describes the general electrostatic and hydrodynamic theory for electrophoresis of slender particles. Yuri Solomentsev presented the paper "Electrophoretic Transport of Slender Nonuniformly Charged Colloids" at the meeting Electrokinetic Phenomena '93 held in Granada, Spain, September, 1993. In January, 1994, John Anderson will present a paper "Electrophoresis of Heterogeneous Aggregates of Colloidal Particles" on this work at the AIAA meeting (Microgravity Science and Space Processing) in Reno.

2. The longer term experimental goals include video-imaging the dynamics of heterogeneous chains and disks in homogeneous, nonhomogeneous and time-dependent electric fields. Both orientation and translation are important. Over the past nine months we have examined video tapes on a frame-by-frame basis to determine the rotation of colloidal doublets formed from two micron-size latex spheres having different zeta potentials (difference is of order 2kT/e). The analysis indicates that the theory (which we developed previously) significantly underpredicts the angular velocity of these doublets. We plan to take more data on this system and also re-examine the theory by allowing for relative slippage between the two spheres of the doublet.

The PI (John Anderson) helps plan and direct the electrophoresis experiments with heterogeneous aggregates of latex. He also works on the theory of slender particles. The co-PI (Steve Garoff) is the primary contributor to the image analysis of the videos. The postdoctoral researcher (Yuri Solomentsev) contributes primarily to the theory for slender particles and does the numerical work. The doctoral student (Darrell Velegol) focuses his attention on the colloidal experiments and the analysis of effects of hydrodynamic slip on the electrophoretic rotation of heterogeneous doublets.